Results in Physics 12 (2019) 1455–1456

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

Microarticle

Tellurium coincidence Doppler broadening spectroscopy study

R. Domínguez-Reyes

Departamento de Física, Universidad Carlos III de Madrid, Avda. de la Universidad 30, 28911 Leganés, Madrid, Spain

ARTICLE INFO

Keywords:
Tellurium
Positron Annihilation Spectroscopy
Doppler broadening spectroscopy

ABSTRACT

The Coincidence Doppler broadening (CDB) reference curve for pure Tellurium (Te) has been obtained stablishing a point of departure for future Positron Annihilation Spectroscopy (PAS) studies of alloys that include Te among its components to determine the influence of this element in the open volume defects and its environment.

Introduction

Te is a p-type semiconductor widely used because its numerous properties such as photoconductivity [1], nonlinear optical responses [2], and high-performance thermoelectric behavior [3] among others. These properties allow Te to be involved in a wide different uses such us solar cells [4]; biological theranostic (therapeutic or diagnostic) applications [5]; or in the new developing high-entropy alloys to improve its mechanical properties [6]. A complete characterization of Te and Te-based materials is required for any further development. PAS allows studying the vacancy-type defects that strongly influence the mechanical properties of metallic alloys [7] and semiconductors [8], nevertheless reference values and curves for pure Te are required and they are not present in literature [9,10]. In this study CDB reference curve corresponding to pure Te has been obtained.

Experimental procedure

The midway position between the two HP Ge detectors (placed face to face separated by 40 cm to each other, and configured in 1 μs timing coincidence) was used as target position for the samples that sandwiched a 0.5 MBq ^{22}Na source sealed in kapton. The 24 spectra taken showed no evidence of electronic shift and had a total number of events around 3×10^7 in the 512×512 coincidence matrix. The obtained cumulative spectra after selecting a strip in the diagonal of the matrix had 1×10^7 counts. The selection window was defined as $2m_oc^2$-1.6 keV $< E_1 + E_2 < 2m_oc^2 + 1.6$ keV, where E_1 and E_2 stand for the energies of the pair of annihilating photons, m_o the electron rest mass and c the light speed. Using a bin width of 2.5×10^{-3} m_o improved the shape of the curve for the resulting data, and then normalized for comparison purposes. As a reference for the above data, 99.999% purity annealed (3 h 400 °C) Al samples (10 mm × 10 mm, 2 mm thick) analogous CDB spectrum was used in order to highlight the signature points of the sample's spectra.

Results

Normalized to pure Al CDB curve for Te (99.999% purity, annealed at 250 °C during 2 h, 7 mm × 7 mm, 5 mm thick) shown in Fig. 1 a) shows a first major peak at $p_L = 15.2(3) \times 10^{-3}$ m_0c and a second peak at $p_L = 21.2(3) \times 10^{-3}$ m_0c followed by a constant decrease in the high-momentum region. Fe and Cu obtained CDB curves displayed in Fig. 1 a) match theoretical calculations [11] confirming the experimental results of the setup. The momentum position of the maximum of the first peak can be placed in the distribution of [10] and compared to the other elements of the $36 < Z < 54$ region that partially share the electronic momentum distribution ([Kr]$5s^1$ to [Kr]$5s^24d^{10}5p^6$). The obtained point, located in the end of the Z-grouped elements, is located on top of the other data following the same tendency of the previous Z region ($18 < Z < 36$) where all the elements showed a quick incensement in the distribution.

Conclusions

CDB spectroscopy has been used to characterize high-purity Te. The obtained Te CDB curve has been validated by the reference plot "position of the first peak of the curve" versus "atomic number Z" [10] obtaining the corresponding new point at $p_L = 15.2(3) \times 10^{-3}$ m_0c. This curve will be used as reference in further studies involving Te-based materials.

Acknowledgments

This research was supported by the Spanish Ministerio de Economia y Competitividad (MINECO) in the form of Project ENE2015-70300-C3-2-R and by the Regional Government of Madrid through the programs S2013/MAE-2745 TECHNOFUSION(II)-CM MINECO/FEDER, and S2013/MIT-2862-MULTIMAT-CHALLENGE.

https://doi.org/10.1016/j.rinp.2019.01.044
Received 9 November 2018; Received in revised form 11 January 2019; Accepted 14 January 2019
Available online 19 January 2019
2211-3797/ © 2019 The Author. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).

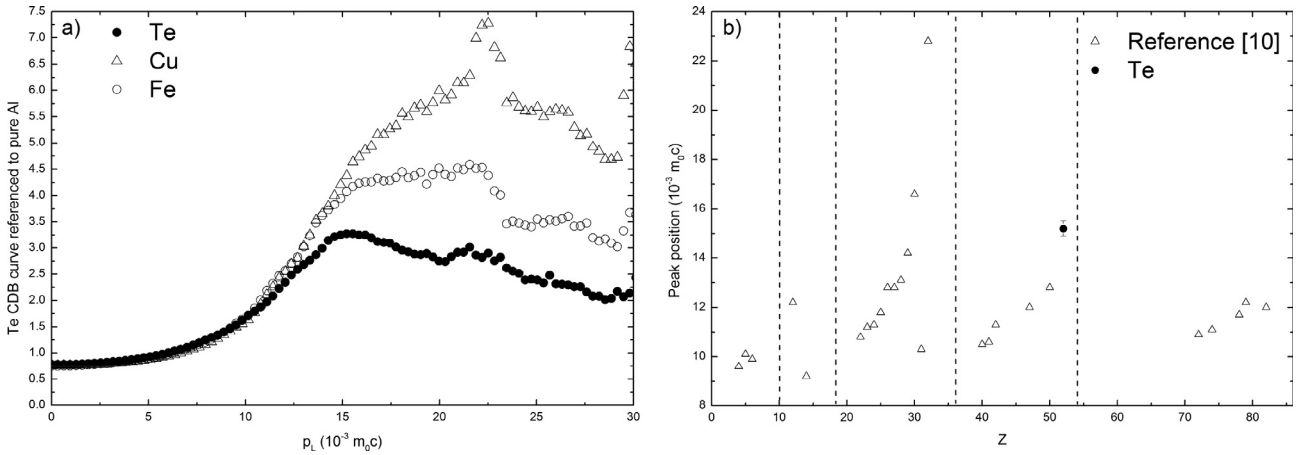

Fig. 1. a) Te CDB curve referenced to pure Al. Fe and Cu CDB curves added for comparison purposes. b) CDB first peak position as a function of atomic number Z. Solid dot correspond to reference [10] and empty dot correspond to this work.

References

[1] Carotenuto G, Palomba M, de Nicola S, Ambrosone G, Coscia U. Nanoscale Res Lett 2015;10:313.
[2] Silva RR, Meija HAG, Ribeiro SJL, Shrestha LK, Ariga K, Oliveira Jr ON, et al. J Braz Chem Soc 2017;28(1):58–67.
[3] Lin S, Li W, Chen Z, Shen J, Ge B, Pei Y. Nat Commun 2016;7:10287.
[4] Panahi-Kalamuei M, Mousavi-Kamazani M, Salavati-Niasari M. JNS 2014;4:459–65.
[5] Shakibaie M, Adeli-Sardou M, Mohammadi-Khorsand T, ZeydabadiNejad M, Amirafzali E, Amirpour-Rostami S, et al. Iran J Biotechnol 2017;15(4):268–76.
[6] Fan Z, Wang H, Wu Y, Liu X, Lu Z. Mater Res Lett 2017;5(3):187–94.
[7] Horodek P, Dryzek J. Surf Coat Technol 2018;355:247–51.
[8] Elsayed M, Krause-Rehberg R. Scr Mater 2017;131:72–5.
[9] Campillo Robles JM, Ogando E, Plazaola F. J Phys: Condens Matter 2007;19:176222. (20pp).
[10] Brusa RS, Deng W, Karwasz GP, Zecca A. Nucl Instrum Methods Phys Res B 2002;194:519–31.
[11] Gosh VJ, Alatalo M, Asoka-Kumar P, Nielsen B, Lynn KG, Kruseman AC, et al. Phys Rev B 2000;61:10092–9.